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EVALUATION OF CIVIL DEFENSE RADIOLOGICAL INSTRUMENTS, (U)
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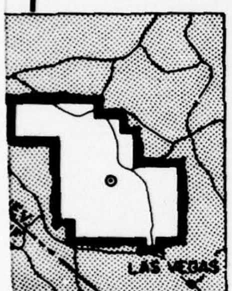

NEVADA TEST SITE
MAY-OCTOBER 1957

Project 35.4

EVALUATION OF CIVIL DEFENSE RADIOLOGICAL INSTRUMENTS

Issuance Date: October 10, 1958

CIVIL EFFECTS TEST GROUP

This is a preliminary report based on all data available at the close of this project's participation in Operation PLUMBBOB. The contents of this report are subject to change upon completion of evaluation for the final report. This preliminary report will be superseded by the publication of the final (WT) report. Conclusions and recommendations drawn herein, if any, are therefore tentative. The work is reported at this early time to provide early test results to those concerned with the effects of nuclear weapons and to provide for an interchange of information between projects for the preparation of final reports.

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AEC Technical Information Service Extension
Oak Ridge, Tennessee

Operation PLUMBBOB Preliminary Report

Project 35.4

EVALUATION OF CIVIL DEFENSE RADIOLOGICAL INSTRUMENTS

By

John H. Tolan and Donald G. Remark

Approved by: James R. Barnett
Director
Program 35

Approved by: R. L. Corsbie
Director
Civil Effects Test Group

Federal Civil Defense Administration

February 1958

ABSTRACT

Experiments were conducted during Operation Plumbbob (1) to investigate the beta-gamma exposure-rate ratio from fallout to establish design criteria for high-range beta-gamma survey instruments and (2) to evaluate existing civil defense radiological instruments.

Results of these investigations confirm results obtained in Operation Teapot (WT-1190). Conclusions reported in WT-1190 were that design criteria for the high-range instrument, CD V-720, agreed with the requirements for such an instrument. The item of major interest was the effect of a 50 mg/cm^2 window on the attenuation of beta radiation from fallout. Experiments showed that the component of the total quantity of beta radiation absorbed by the window, and not indicated by the instrument, was small enough that its contribution to the total hazard was insignificant.

Recommendations made in WT-1190 were to (1) develop satisfactory instrument-calibration facilities and (2) use sealed ionization chambers to eliminate the change in sensitivity of survey meters as a function of altitude. These recommendations were accepted and incorporated in ionization type survey-meter specifications. The recommendation that an operational check or circuit check rather than a simple battery check be provided for all survey meters was also incorporated in instrument specifications.

In addition to evaluating FCDA Standard Item Specification Instruments, sample instruments supplied by the British civil defense organization were evaluated. These instruments have performance characteristics similar to FCDA instruments, but they are more difficult to operate.

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ILLUSTRATIONS

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Chapter 1

INTRODUCTION

1.1 OBJECTIVES

Objectives of Project 35.4 were (1) to study radiation characteristics of fallout materials as related to penetrability vs. time immediately postshot and (2) to evaluate the performance of radiological defense instruments in field use. The information obtained in (1) provides the operating criteria for (2). If all instruments (CD V-700, CD V-710, and CD V-720) satisfactorily respond to biologically hazardous radiation, then each has performed its function. If the variations of instrument response to different radiation characteristics can be predicted, then the instruments will provide information to assist in evaluating the biological hazard.

1.2 BACKGROUND

The Federal Civil Defense Administration has for several years been engaged in a long-range program of radiological instrument development, procurement, and distribution for emergency use. Early specifications for instrument design were based on the only experience available, that of the national laboratories operated by the Atomic Energy Commission and other similar organizations such as the National Bureau of Standards. This experience was different from that anticipated for civil defense operations. To improve the knowledge in this field, arrangements were made to participate in the weapons test programs at the Nevada Test Site and the Pacific Proving Ground. Participation as test observers provided FCDA personnel with enough information to prepare preliminary design specifications for some instrument types. These instruments were produced in limited quantities and were used for further investigations.

Evaluation studies were conducted using these instruments during Operation Upshot-Knothole[1] in 1953. The results of these tests pro-

vided the basis for improved instrument design.

Improved instruments and prototype instruments of different types were evaluated during Operation Teapot[2] in 1955. In addition to the evaluation of instruments already in production, a cursory evaluation of a CD V-720 prototype unit was made. Studies of radiation characteristics of fallout materials were made to determine required response characteristics of high-range instruments. Results of the studies were most interesting, but they were inconclusive because of limited shot participation. This report gives results of the latest efforts to evaluate FCDA instruments.

REFERENCES

1. Various Aspects of Nuclear Radiation Measurements for Civil Defense Radiological Defense Purposes, Operation Upshot-Knothole Report, WT-805.

2. Evaluation of Civil Defense Radiological Defense Instruments, Operation Teapot Report, WT-1190.

Chapter 2

BETA-GAMMA EXPOSURE RATE

2.1 OPERATIONAL PROCEDURE

The beta-absorption instrument shown in Fig. 2.1 was designed and fabricated for this project by the Instrument Division, Brookhaven National Laboratory. Except for minor modifications, the instrument is identical to the one used during Operation Teapot and described in WT-1190. It consists of an aluminum block containing seven identical parallel-plate ionization chambers 1.5 cm deep by 15 cm in diameter with aluminum absorbers increasing in thickness by factors of 2 from 7 mg/cm^2 to 440 mg/cm^2. An additional absorber of 440 mg/cm^2 thickness was inserted under the ionization chamber block to increase the absorber range to 880 mg/cm^2. A separate electrometer input circuit was wired in a Lubrifilm-covered block at the collector of each chamber. A remote unit contained a single final amplifier stage for all the electrometer stages, a sensitivity switch, an absorber-chamber selection switch, and zero-adjustment potentiometers for each of the seven chamber electrometers. The input resistors of the six chambers not in use were shorted out by Victoreen remote-control switches, and the input resistor of the unit in use could be shorted out by the push-button switch for zero adjustment of its electrometer.

To obtain biological-hazard data, the unit was placed successively on each of three tables, 12, 30, and 60 in. above the ground, representing the lower, middle, and upper portions of a standing human. The tables are shown in Fig. 2.2. Intensity measurements were made for eight separate absorber thicknesses at each of the three elevations. A plot of this information defines the radiation field as a function of energy and elevation above the surface. Subsequent measurements at the same point define the radiation field as a function of time.

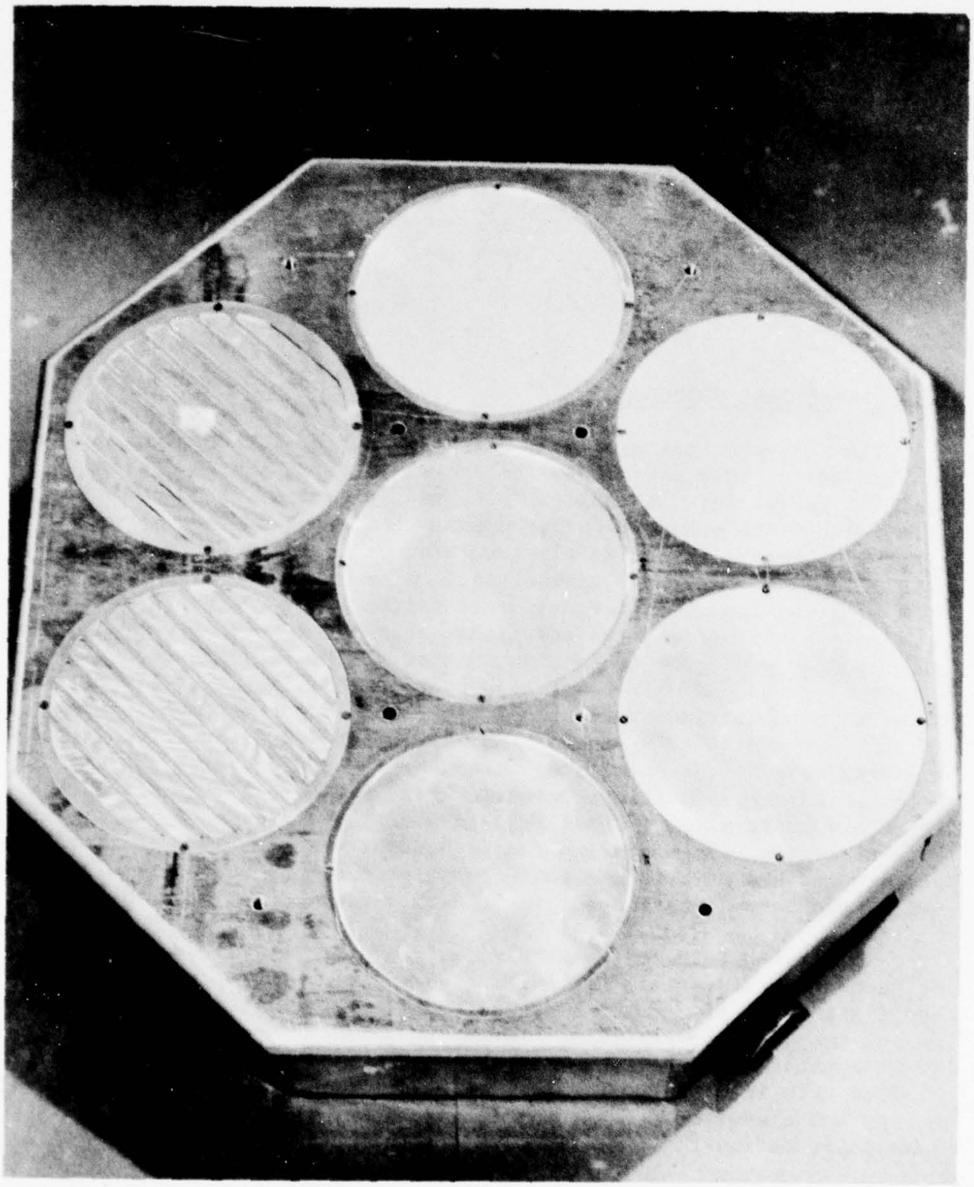

Fig. 2.1--Beta instrument.

Fig. 2.2--Table mounts for beta-absorption instrument. The instrument can be seen mounted on center table.

2.2 RESULTS

Results of measurements made during Operation Plumbbob confirmed the data obtained in Operation Teapot. Data were collected from one tower shot and one balloon shot. The tower shot produced heavy fallout of fission-product activity on-site. This fallout contained an intense and penetrating beta-radiation component. There was an absence of beta activity in material from the balloon shot at sampling locations. The radiation encountered was apparently due mostly to neutron-induced activity.

Beta-absorption data from Appendix A are plotted in Figs. 2.3, 2.5, and 2.7. Figures 2.3 and 2.5 present data from stations 1 and 2, which were along the fallout path from the tower shot; and Fig. 2.7 presents data from station 3, which was in the radiation field from the balloon shot. Table 3.1 presents readings from portable survey meters taken at the same time and place as the data presented in Figs. 2.3 and 2.5. Figures 2.4 and 2.6 present the components of total beta and gamma radiation that penetrate absorbers of 50, 100, 200, and 400 mg/cm^2 thickness compared to the gamma radiation penetrating an absorber of 1000 mg/cm^2 thickness plotted as a function of time postshot. The straight line representing reduction of gamma intensity as a function of time follows $t^{-1.2}$ for this time interval. Because curves representing beta penetration contain this gamma component as well, the curves will approach the gamma radiation approximately three days postshot. Thus the curves plotted in Figs. 2.4 and 2.6 show the variable portion of the beta intensity vs. time relation. The relative intensities of beta radiation having sufficient energy to penetrate 200 and 400 mg/cm^2 diminish rapidly, but less energetic beta radiation, after an initial decrease, apparently follows the same decay as gamma radiation.

Beta-gamma intensities plotted in Figs. 2.3 to 2.7 are given in rads per hour rather than roentgens per hour to overcome the obvious shortcoming of presenting beta-radiation intensity in units not defined for beta radiation. Chambers used in absorption measurements were air-filled at atmospheric pressure and were calibrated in terms of their response to Co^{60} gamma radiation in roentgens per hour. Response of such a chamber to beta radiation should be such that 1 rep/hr of beta radiation produces the same ionization current as 1 r/hr of gamma radiation. Thus, 1 rep of beta = 1 r of gamma = 83 ergs/g of air. The over-all instrument indication is given in roentgens per hour, representing the sum of gamma intensity and equivalent beta intensity. Consequently, a conversion of rep to rad and roentgen to rad would be the ratio of 83 ergs/g to 100 ergs/g. The instrument calibration given in roentgens per hour per unit of scale deflection is converted to rads per hour per unit of scale deflection by incorporating the factor 83/100. The absolute magnitude of radiation intensity is academic because it is the relative intensity of beta to gamma radiation that is

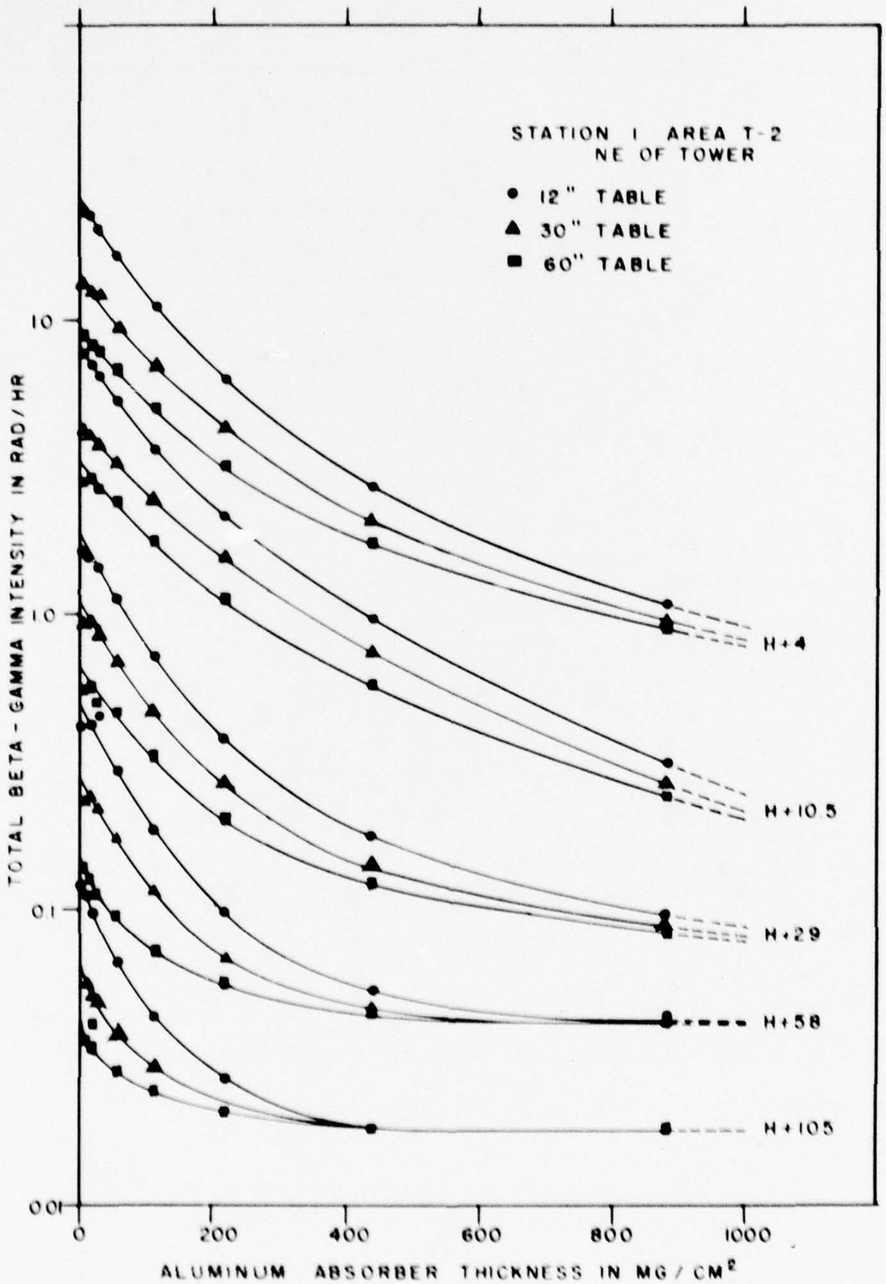

Fig. 2.3--Beta absorption curves, station 1.

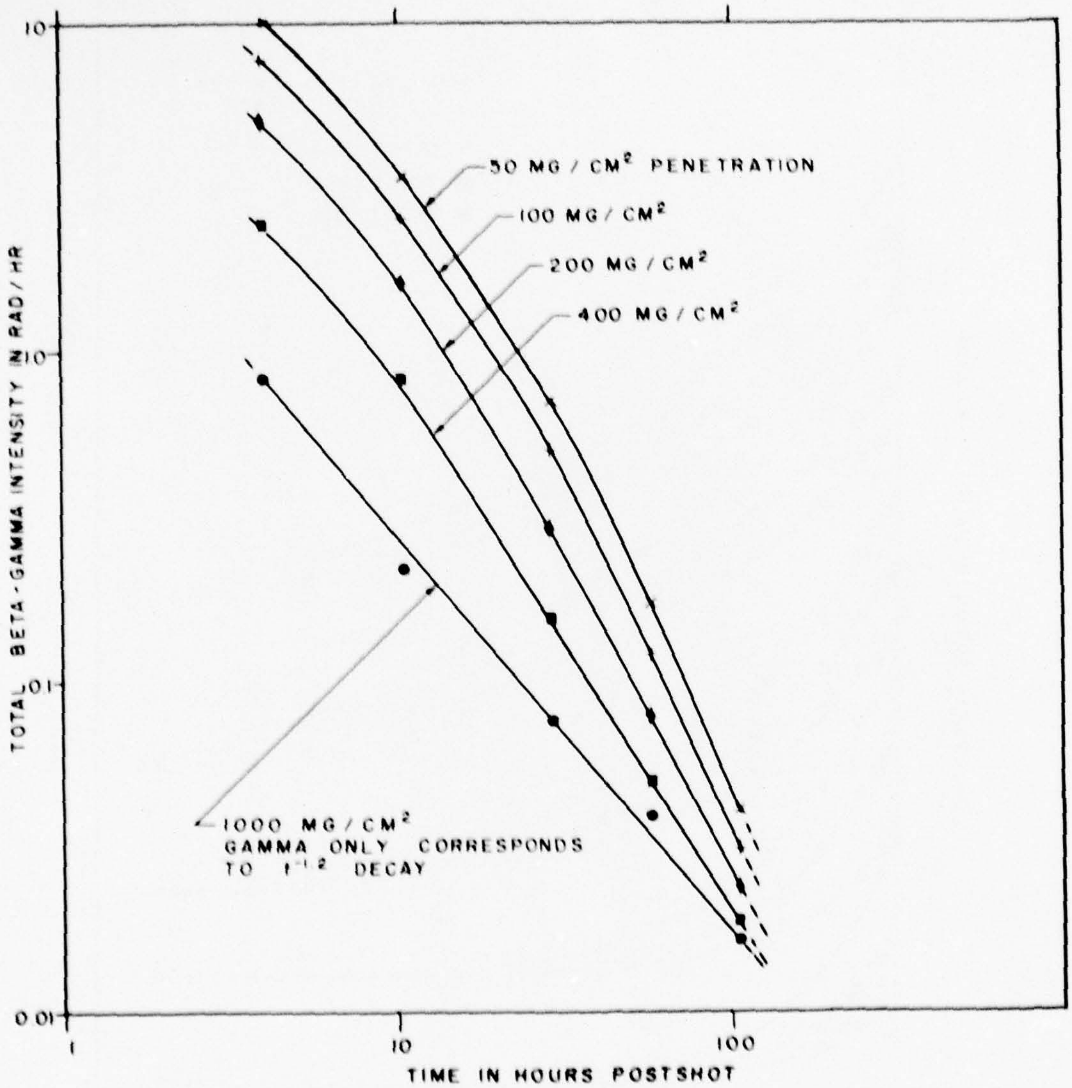

Fig. 2.4--Comparison of beta penetration as a function of time. Station 1, 30 in. table.

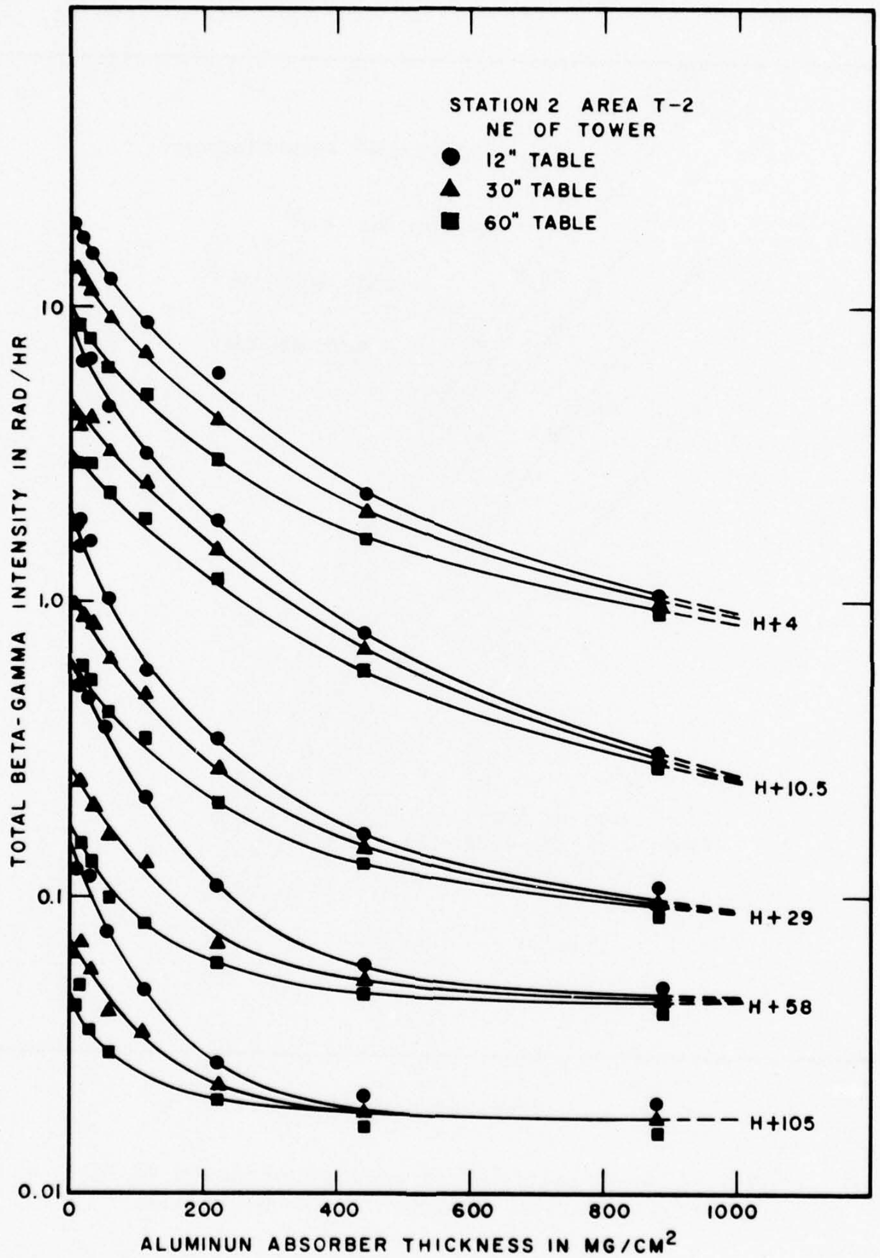

Fig. 2.5--Beta absorption curves, station 2.

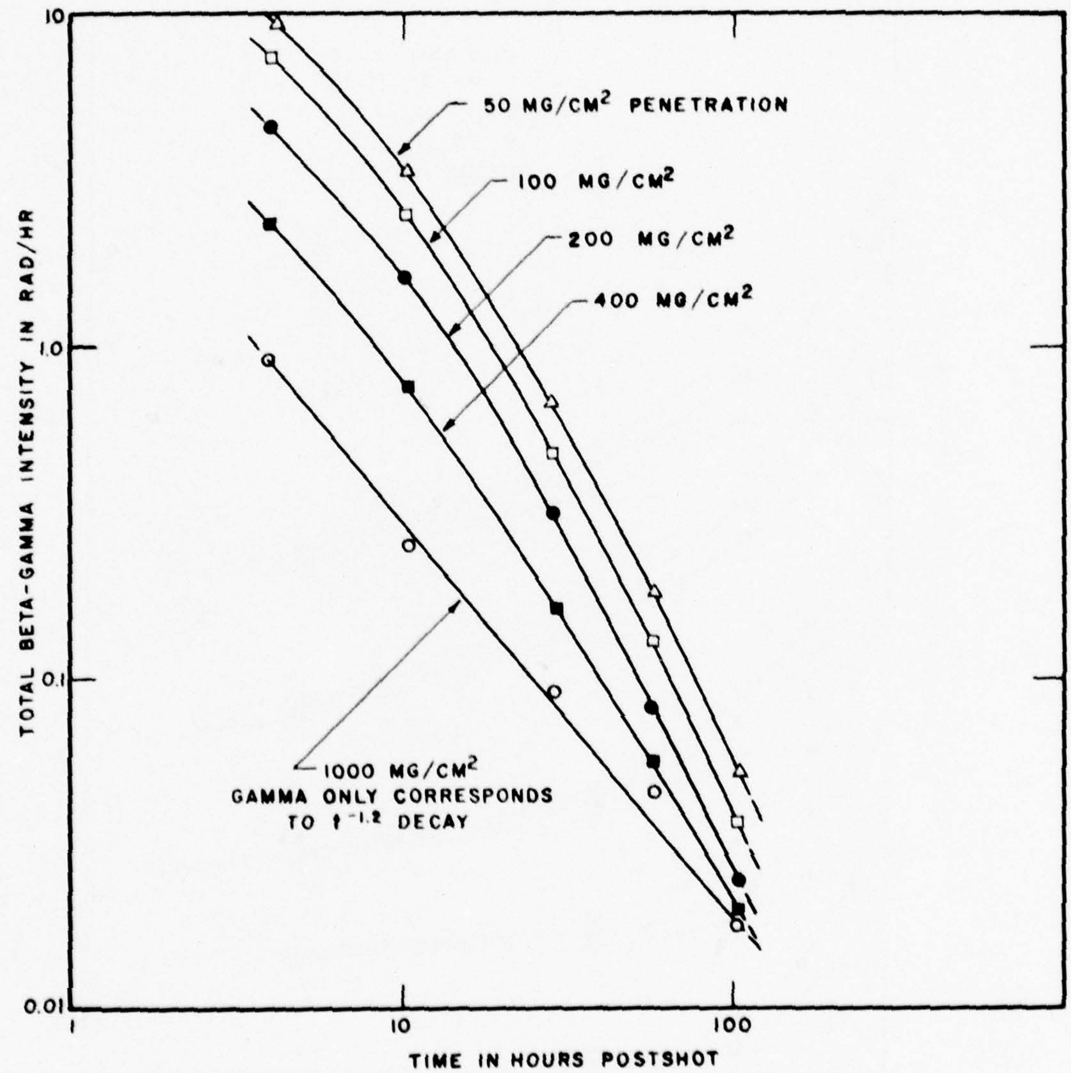

Fig. 2.6--Comparison of beta penetration as a function of time. Station 2, 30 in. table.

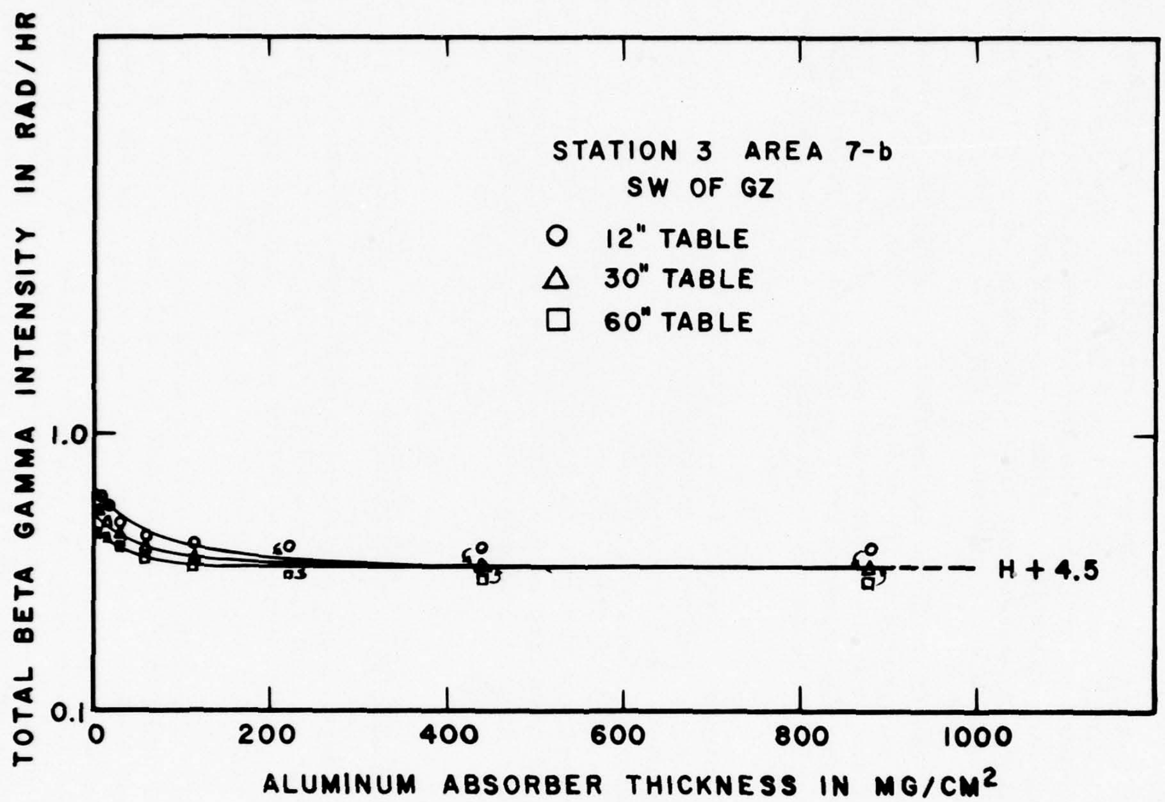

Fig. 2.7--Beta absorption curves, station 3.

sought in the data.

2.3 DISCUSSION

The high-range beta-gamma discriminating CD V-720 ionization-chamber instrument was designed as a limited-use instrument intended for measurements of fallout radiation containing a large component of penetrating beta radiation. Teams using such an instrument should be better trained in measurement techniques than those trained only to perform measurements with the medium-range CD V-710.

To use the CD V-720 to its maximum capacity, the operator should have a good background in the radiation sciences and be thoroughly briefed on how beta and gamma radiation affects instrument readings. He should know the exposure criteria for beta and gamma radiation and should be able to judge safe operating practices for each radiological situation.

The biological significance of beta radiation as an external hazard has not been completely determined, and conclusions based on the data given do not indicate what portion of beta radiation emitted by fallout material should be indicated by the instrument. For some times immediately postshot the intensity of beta radiation having sufficient range to penetrate the skin is a factor of 10 or more greater than the intensity of gamma radiation. This is a significant quantity even if partial shielding of clothing and higher tolerance of skin are taken into consideration.

2.4 CONCLUSIONS AND RECOMMENDATIONS

Field data of the characteristics of beta radiation compared to gamma radiation from fission-product activity are now essentially complete. From this information the response characteristics of an instrument that will indicate the biological hazard can be determined.

The special instrument used in these measurements has been calibrated for gamma radiation but not for beta radiation. Such a calibration is not a simple matter because the geometry of the field measurements must be approximated. Also, this beta calibration will require a correlation between beta and gamma intensities for several beta energies representing, for example, ranges of 50, 100, 200, and 400 mg/cm^2. The authors understand that such a calibration will be performed.

Chapter 3

RADIOLOGICAL DEFENSE INSTRUMENT EVALUATION

3.1 OPERATIONAL PROCEDURE

Radiological survey meters manufactured according to FCDA Standard Items Specifications (CD V-700, CD V-710, and CD V-720) were the instruments evaluated in this phase of the project. The instruments are shown in Fig. 3.1. The CD V-700 is a Geiger-tube instrument having three ranges: 0 to 0.5, 0 to 5, and 0 to 50 mr/hr. The probe has a rotating shield over a thin-wall section of the tube so that both beta and gamma may be detected. The CD V-710 is a medium-range ionization-chamber instrument with ranges of 0 to 0.5, 0 to 5, and 0 to 50 r/hr. The CD V-720 is a high-range ionization-chamber instrument having ranges of 0 to 5, 0 to 50, and 0 to 500 r/hr. The V-720 ionization chamber has a 50 per cent window area with a thickness less than 50 mg/cm^2 thick so that beta particles can be detected. The ionization chamber is covered by a sliding shield greater than 1000 mg/cm^2 thick so that the beta particles may be effectively discriminated against when measuring gamma radiation.

Participants of Project 36.1 were assigned instruments to be used during their activities at the Nevada Test Site. The participants of Project 36.1 were assigned to the technical projects of Program 35 as support personnel. These projects involved field exercises in areas having radiation intensities from practically zero to several roentgens per hour. The participants were able to operate the instruments at the low, medium, and high intensities for which the V-700, V-710, and V-720 were intended, thus gaining good experience in meter operation.

Each participant recorded his comments on each type of instrument on the form shown in Appendix B.

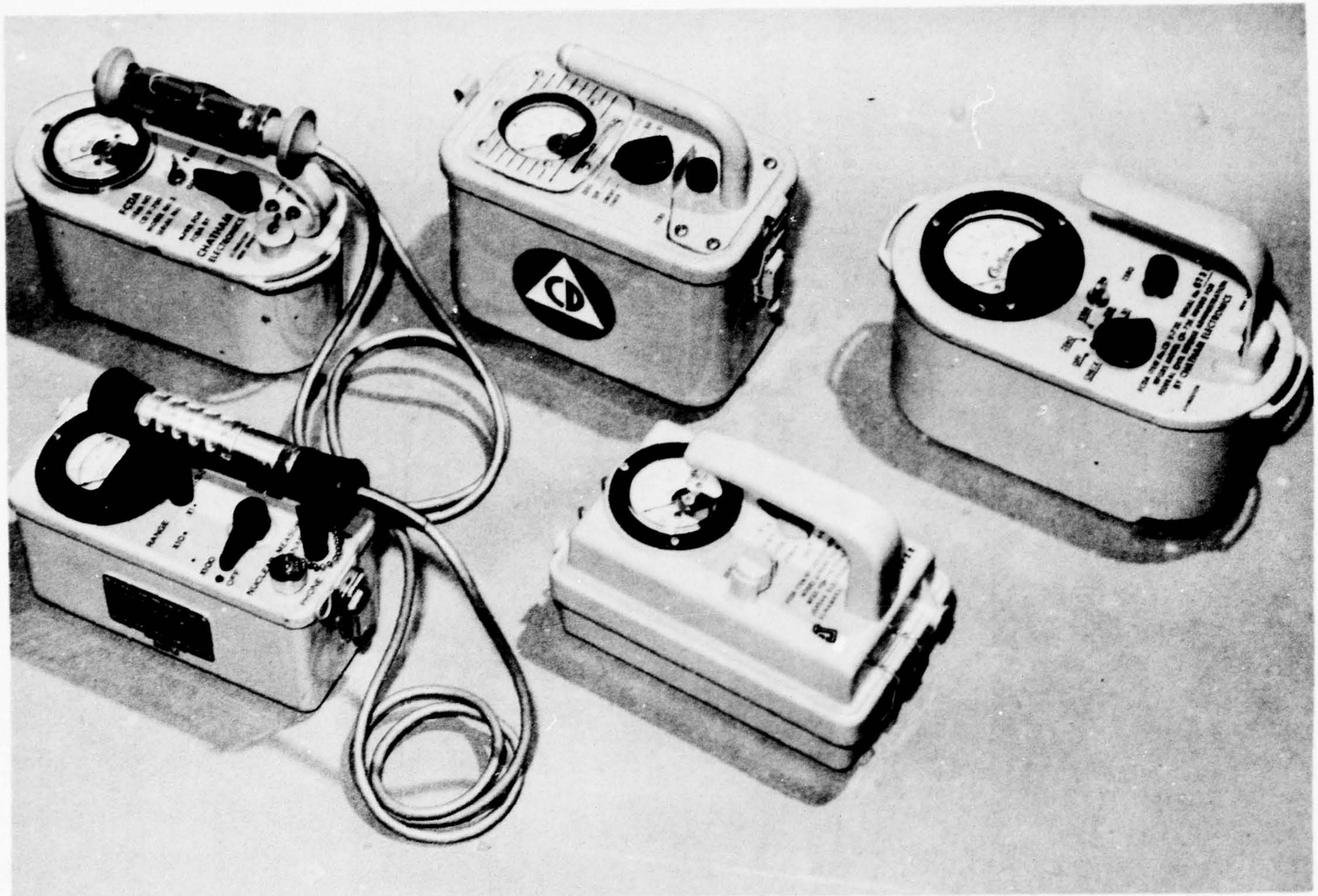

Fig. 3.1--FCDA radiation survey meters: (a) two CD V-700 meters; (b) two CD V-710 meters; and (c) one CD V-720 meter.

3.2 RESULTS

Two remarks regarding instrument construction were made many times by Program 36 participants: (1) the carrying straps were of no help and generally got in the way and (2) the meters should use a logarithmic scale so that it would not be necessary to switch ranges. The zero set on the CD V-710 model 2 drifted downscale at a rate requiring a zero adjustment every 15 to 30 min. Plastics used in battery jackets, battery straps, and carrying straps showed very little strength in the 90° plus temperatures encountered in Nevada. Some easy means of distinguishing between "off" and "on" should be provided; it was difficult to tell whether an instrument was turned on or off. A 90° angle between off and the first of the ranges was suggested.

Only the Meter Survey Radiac No. 2 British instrument was used in the field (Fig. 3.2). This instrument is an ionization chamber having three ranges: 0 to 3, 0 to 30, and 0 to 300 r/hr. The instrument has a beta window that is exposed by removing six screws and taking the bottom plate off. Two instruments of this type were available, and the best calibration that could be obtained was an indication 33 per cent low on Co^{60} radiation. Comparison readings from two CD V-720, one CD V-710, and two British instruments converted to rads per hour are given in Table 3.1. The low readings of the British instruments were due apparently to an altitude effect because the beta window developed appreciable bulges in the 4000- to 6000-ft altitude at the Test Site.

The Meter Contamination No. 1 Mark 2 is a Geiger-tube instrument having a range of 0.1 to 10 mr/hr on a logarithmic scale. This instrument is designed for use in a fixed location rather than in field surveys. It weighs 14 pounds and has an exposed Geiger tube, making fixed usage necessary (see Fig. 3.3). The tubes furnished with the instruments had a thick rubber covering, which effectively shielded all beta particles.

3.3 DISCUSSION

Participants evaluating the instruments were technically trained in fields related to radiological defense. They were qualified instrument operators, and their comments regarding the instruments and their use under the conditions existing at the Test Site reflect this background training. However, the information obtained was not complete because the instruments were not used to the limits of their battery life and were not continuously subjected to the rough treatment incident to emergency use.

The instruments were used for short periods to protect the monitors from radiation exposures that would result from longer periods in the field. The maximum continuous use was 2 hr. Usually they were

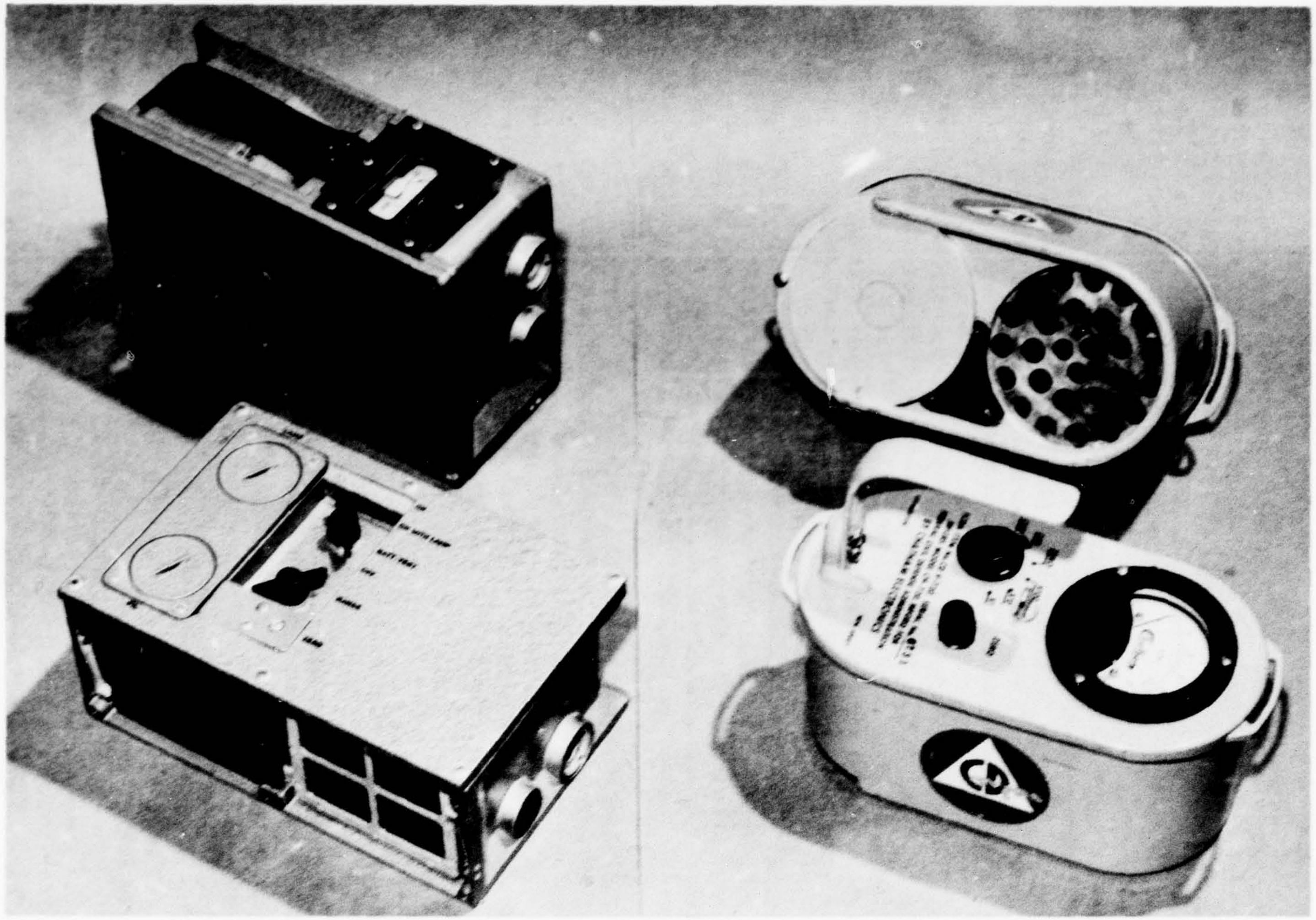

Fig. 3.2--British Meter Survey Radiac No. 2 (left) and FCDA CD V-720 (right). Both show exposed beta window.

Table 3.1--RESPONSE OF CD V-710, CD V-720 AND BRITISH INSTRUMENTS (MRAD/HR)*

Time Postshot		CD V-720		British		CD V-710
			Station 1			
		Ser. 6734	Ser. 6750	Ser. 32154	Ser. 32145	
H + 4	a.	950	1160	950	800	1040
	b.	2800	3300	1950	1750	
H + 10.5	a.	330	370	250	210	315
	b.	1000	1040	750	620	
H + 29	a.	165	210	83	50	100
	b.	250	330	165	110	
			Station 2			
H + 4	a.	1000	1150	950	790	950
	b.	2700	3100	2000	1750	
H + 10.5	a.	330	350	290	210	330
	b.	1080	1000	790	660	
H + 29	a.	165	250	125	66	105
	b.	250	370	210	125	

*Compare with Figs. 2.3 and 2.7.

NOTE: a. Window closed.
b. Window open.

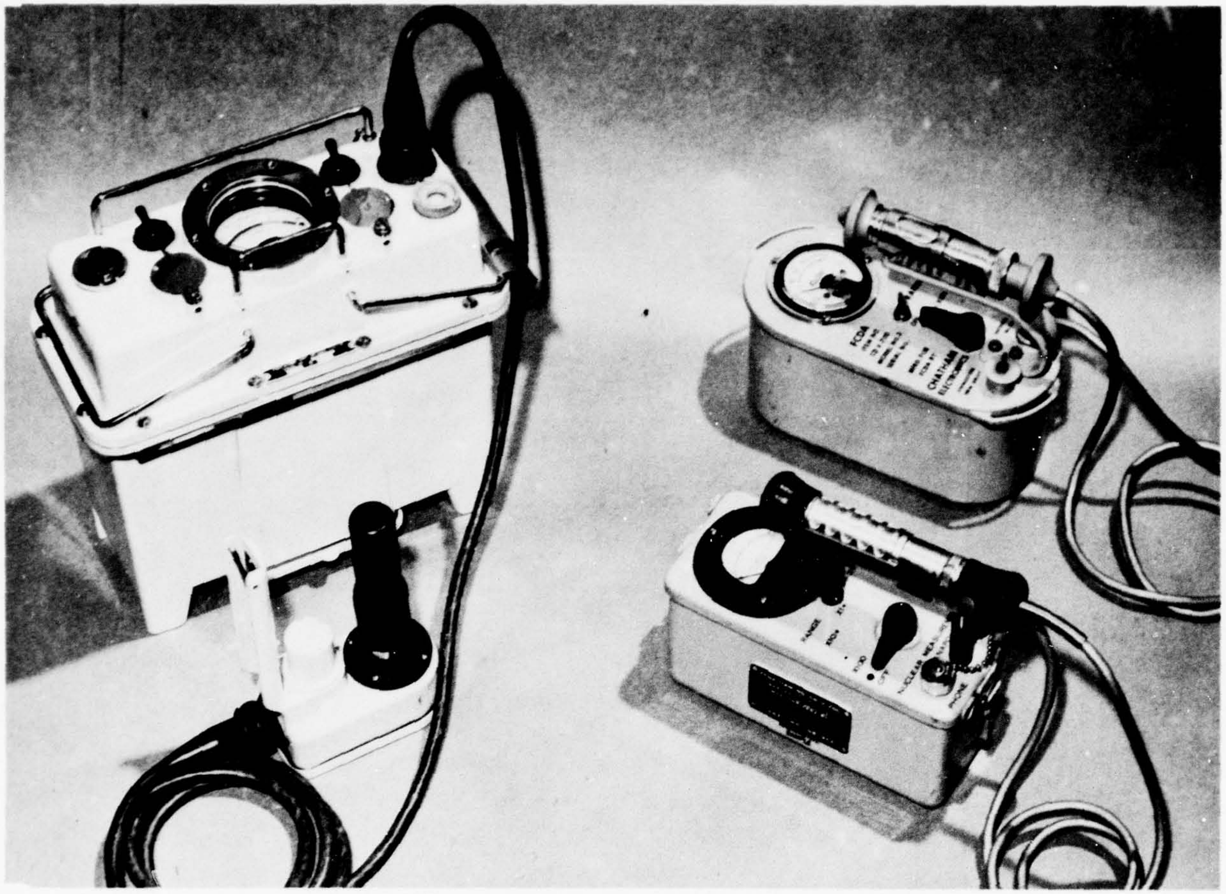

Fig. 3.3--British Meter Contamination No. 1
Mark 2 (left) and FCDA CD V-700 (right).

operated for about 30 min a period for a total use of 2 to 3 hr.

3.4 CONCLUSIONS

The efforts of Project 35.4 to evaluate FCDA instruments as they are used in training programs at the Nevada Test Site should be continued. Models 1 and 2 of CD V-700 and model 2 CD V-710 were the only instruments of this type available for the tests. The quantity of CD V-700's used for the test represents only 10 per cent of the total quantity of CD V-700's ordered by the FCDA. This is not truly representative of FCDA models in the instrument program. Model 4 CD V-700 and model 5 CD V-710 are in production and are scheduled for early distribution.

The evaluation sheets were made general enough so that comments made on the models used can be applied to the new models. A true evaluation would require comparison of the various FCDA types under service conditions. The comparison should be made with instruments having the same ranges but different circuit and design criteria.

Appendix A

BETA-ABSORPTION MEASUREMENTS

Table A.1--STATION 1 DATA

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+4 hr	12"	7	4900	5.0	25
		6	4500	5.0	23
		5	9500	2.2	21
		4	7600	2.05	16
		3	>10000	1.1	11
		2	6600	1.0	6.6
		1	7000	0.39	2.7
		8	2800	0.39	1.1
	30"	7	2700	5.0	13.5
		6	2600	5.0	13
		5	5600	2.2	12.3
		4	4600	2.05	9.4
		3	6800	1.1	7.5
		2	4500	1.0	4.5
		1	5300	0.39	2.1
		8	2600	0.39	1.0
	60"	7	1750	5.0	8.7
		6	1700	5.0	8.5
		5	3650	2.2	8.0
		4	3100	2.05	6.3
		3	4600	1.1	5.1
		2	3200	1.0	3.2
		1	4200	0.39	1.8
		8	2400	0.39	0.94

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.1--(Continued)

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+10.5 hr	12"	7	1500	5.0	7.5
		6	1450	5.0	7.3
		5	2800	2.2	6.2
		4	2450	2.05	5.0
		3	3700	1.1	4.1
		2	2100	1.0	2.1
		1	2500	0.39	0.97
		8	820	0.39	0.32
	30"	7	840	5.0	4.2
		6	840	5.0	4.2
		5	1900	2.2	4.2
		4	1600	2.05	3.3
		3	2400	1.1	2.6
		2	1600	1.0	1.6
		1	1850	0.39	0.72
		8	720	0.39	0.28
	60"	7	560	5.0	2.8
		6	550	5.0	2.7
		5	1300	2.2	2.9
		4	1100	2.05	2.3
		3	1700	1.1	1.9
		2	1200	1.0	1.2
		1	1400	0.39	0.55
		8	660	0.39	0.26

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.1--(Continued)

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+29 hr	12"	7	315	5.0	1.6
		6	345	5.0	1.7
		5	605	2.2	1.33
		4	520	2.05	1.07
		3	720	1.1	0.79
		2	380	1.0	0.38
		1	460	0.39	0.18
		8	245	0.39	0.096
	30"	7	185	5.0	0.93
		6	190	5.0	0.95
		5	375	2.2	0.83
		4	315	2.05	0.65
		3	450	1.1	0.49
		2	275	1.0	0.27
		1	360	0.39	0.14
		8	230	0.39	0.090
	60"	7	110	5.0	0.55
		6	115	5.0	0.57
		5	235	2.2	0.52
		4	200	2.05	0.50
		3	290	1.1	0.32
		2	200	1.0	0.20
		1	310	0.39	0.12
		8	220	0.39	0.086

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.1--(Continued)

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+58 hr	12"	7	97	5.0	0.49
		6	82	5.0	0.41
		5	220	2.2	0.48
		4	160	2.05	0.33
		3	190	1.1	0.21
		2	100	1.0	0.10
		1	140	0.39	0.055
		8	110	0.39	0.043
	30"	7	46	5.0	0.23
		6	48	5.0	0.24
		5	100	2.2	0.22
		4	76	2.05	0.16
		3	120	1.1	0.13
		2	67	1.0	0.067
		1	125	0.39	0.049
		8	100	0.39	0.039
	60"	7	27	5.0	0.135
		6	28	5.0	0.14
		5	54	2.2	0.12
		4	46	2.05	0.099
		3	70	1.1	0.077
		2	54	1.0	0.054
		1	120	0.39	0.047
		8	100	0.39	0.039

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.1--(Continued)

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+105 hr	12"	7	28	5.0	0.140
		6	23	5.0	0.115
		5	52	2.2	0.115
		4	36	2.05	0.074
		3	44	1.1	0.048
		2	26	1.0	0.026
		1	48	0.39	0.018
		8	40	0.39	0.018
	30"	7	11	5.0	0.055
		6	12	5.0	0.060
		5	23	2.2	0.051
		4	17	2.05	0.035
		3	29	1.1	0.032
		2	21	1.0	0.021
		1	41	0.39	0.018
		8	40	0.39	0.018
	60"	7	7.5	5.0	0.038
		6	9	5.0	0.045
		5	15	2.2	0.033
		4	13	2.05	0.027
		3	22	1.1	0.024
		2	21	1.0	0.021
		1	43	0.39	0.018
		8	42	0.39	0.018

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.2--STATION 2 DATA

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+4 hr	12"	7	3900	5.0	19.5
		6	3400	5.0	17
		5	6850	2.2	15
		4	6000	2.05	12.3
		3	8000	1.1	8.8
		2	5900	1.0	5.9
		1	5900	0.39	2.3
		8	2700	0.39	1.05
	30"	7	2600	5.0	13
		6	2500	5.0	12.5
		5	5400	2.2	11.9
		4	4400	2.05	9.0
		3	6400	1.1	7.0
		2	4200	1.0	4.2
		1	5200	0.39	2.0
		8	2600	0.39	1.01
	60"	7	1700	5.0	8.5
		6	1700	5.0	8.5
		5	3550	2.2	7.8
		4	3000	2.05	6.2
		3	4500	1.1	5.0
		2	3100	1.0	3.1
		1	4200	0.39	1.6
		8	2400	0.39	0.94

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.2--(Continued)

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+10.5 hr	12"	7	1600	5.0	8.0
		6	1300	5.0	6.5
		5	3050	2.2	6.7
		4	2250	2.05	4.6
		3	2900	1.1	3.2
		2	1850	1.0	1.9
		1	2000	0.39	0.78
		8	790	0.39	0.31
	30"	7	840	5.0	4.2
		6	805	5.0	4.0
		5	1900	2.2	4.2
		4	1550	2.05	3.2
		3	2300	1.1	2.5
		2	1500	1.0	1.5
		1	1800	0.39	0.70
		8	760	0.39	0.30
	60"	7	580	5.0	2.9
		6	570	5.0	2.9
		5	1300	2.2	2.9
		4	1100	2.05	2.3
		3	1700	1.1	1.9
		2	1200	1.0	1.2
		1	1500	0.39	0.59
		8	720	0.39	0.28

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.2--(Continued)

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+29 hr	12"	7	370	5.0	1.85
		6	310	5.0	1.55
		5	730	2.2	1.60
		4	500	2.05	1.03
		3	540	1.1	0.59
		2	350	1.0	0.35
		1	400	0.39	0.16
		8	250	0.39	0.098
	30"	7	190	5.0	0.95
		6	180	5.0	0.90
		5	380	2.2	0.84
		4	310	2.05	0.64
		3	440	1.1	0.48
		2	270	1.0	0.27
		1	380	0.39	0.15
		8	250	0.39	0.098
	60"	7	120	5.0	0.60
		6	120	5.0	0.60
		5	240	2.2	0.53
		4	200	2.05	0.41
		3	310	1.1	0.34
		2	210	1.0	0.21
		1	340	0.39	0.13
		8	245	0.39	0.096

*Dose rate = $c \times \mu a \times 10^{-3}$ rad/hr.

Table A.2--(Continued)

Time	Table	Chamber	Response, µa	Conversion, c	*Dose rate, rad/hr
H+58 hr	12"	7	110	5.0	0.55
		6	105	5.0	0.53
		5	220	2.2	0.48
		4	190	2.05	0.39
		3	200	1.1	0.22
		2	115	1.0	0.11
		1	150	0.39	0.059
		8	120	0.39	0.047
	30"	7	47	5.0	0.24
		6	47	5.0	0.24
		5	92	2.2	0.20
		4	76	2.05	0.16
		3	120	1.1	0.13
		2	70	1.0	0.070
		1	135	0.39	0.053
		8	110	0.39	0.043
	60"	7	29	5.0	0.15
		6	30	5.0	0.15
		5	58	2.2	0.13
		4	48	2.05	0.098
		3	74	1.1	0.081
		2	58	1.0	0.058
		1	135	0.39	0.053
		8	120	0.39	0.047

*Dose rate = c x µa x 10^{-3} rad/hr.

Table A.2--(Continued)

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+105 hr	12"	7	25	5.0	0.125
		6	28	5.0	0.14
		5	56	2.2	0.12
		4	37	2.05	0.076
		3	44	1.1	0.048
		2	27	1.0	0.027
		1	50	0.39	0.019
		8	46	0.39	0.018
	30"	7	13	5.0	0.065
		6	14	5.0	0.070
		5	26	2.2	0.057
		4	20	2.05	0.041
		3	32	1.1	0.035
		2	23	1.0	0.023
		1	50	0.39	0.019
		8	46	0.39	0.018
	60"	7	8.5	5.0	0.043
		6	10	5.0	0.050
		5	16	2.2	0.035
		4	14	2.05	0.029
		3	28	1.1	0.031
		2	22	1.0	0.022
		1	50	0.39	0.019
		8	46	0.39	0.018

*Dose rate = c x μa x 10^{-3} rad/hr.

Table A.3--STATION 3 DATA

Time	Table	Chamber	Response, μa	Conversion, c	*Dose rate, rad/hr
H+4.5 hr	12"	7	140	5.0	0.70
		6	135	5.0	0.67
		5	270	2.2	0.59
		4	260	2.05	0.53
		3	490	1.1	0.54
		2	490	1.0	0.49
		1	1250	0.39	0.49
		8	1200	0.39	0.47
	30"	7	130	5.0	0.65
		6	130	5.0	0.65
		5	260	2.2	0.57
		4	250	2.05	0.51
		3	470	1.1	0.52
		2	480	1.0	0.48
		1	1200	0.39	0.47
		8	1200	0.39	0.47
	60"	7	125	5.0	0.63
		6	130	5.0	0.65
		5	245	2.2	0.54
		4	240	2.05	0.49
		3	460	1.1	0.51
		2	470	1.0	0.47
		1	1200	0.39	0.47
		8	1150	0.39	0.45

*Dose rate = c x μa x 10^{-3} rad/hr.

Appendix B

FCDA INSTRUMENT-EVALUATION QUESTIONNAIRE

PROGRAM 35
Project 35.4

FCDA INSTRUMENT-EVALUATION QUESTIONNAIRE

Reporter's Name ______________________________ Date ______________________

Instrument Type Number CD V-_________________ Model No. ________________

Serial No. ___________________________________

1. Was the instrument response ___ too fast, ___ proper, ___ too slow?

   COMMENTS:

2. (a) Was instrument easily calibrated?

   (b) If not, what would you recommend?

3. (a) How long was the instrument turned on during the day?

   ___ Hours.

   (b) Did you leave it on ___ continuously or ___ turn it off after each reading or series of readings?

4. (a) If this report is on a 710 or 720, did the instrument require frequent zeroing? _________________.

   (b) How often was zeroing needed during the first 30 minutes? ____

   (c) After the first 30 minutes approximately how often did the instrument need zeroing? Every _______ minutes.

(d) Was the meter drift __________ up or __________ down-scale?

COMMENTS:

5. Was the instrument easily read when carried by the handle _______, the carrying strap ________?

COMMENTS:

6. Do you think some other graduation and/or markings should be used on the meter?

7. Have you had previous experience with portable survey meters? ____ If other than FCDA instruments, please indicate types and compare them to this instrument. (Convenience of use, readability, stability, malfunctioning, etc.)

8. Are there design or circuit features which you believe should be changed to facilitate field usage?

9. Did the battery life seem sufficient?

Use the back of questionnaire if additional space is required.